Report to UM Independent System for Peer Reviews

Review of

Eastern Tropical Pacific Ecosystems Studies

at the

Southwest Fisheries Science Center
National Marine Fisheries Service
La Jolla, California

By

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Executive Summary

The environmental data gathered in the Monitoring of Porpoise Stocks (MOPS) and the *Stenella* Abundance Research (STAR) programs provide extremely important time series for examining correlations between variability in the marine climate and the responses of upper trophic level organisms to ecosystem change. These ecosystem indices for the eastern tropical Pacific (ETP), including physical measurements, chlorophyll abundance, ichthyoplankton abundance, and the distributions and abundances of seabirds and cetaceans, all suggest a system that is relatively stable, and that has its strongest temporal responses at the time scale of El Niño/Southern Oscillation (ENSO) events. There is little evidence to support a strong environmental change between the MOPS study (1986-1990) and the STAR study (1998-2000). However, the time series are too short to address the question of whether there has been a significant change in the marine ecosystem between the time when spotted (*Stenella attenuata)* and spinner dolphins (*S. longirostris*) were abundant in the ETP (e.g., prior to the 1970s) and more recent times. Nevertheless, it may be possible to extract additional information from existing data sets that could help to resolve whether there have been significant changes in the marine ecosystem over this period. Recommendations for representative analyses are provided. Ultimately, if it is important to determine the causal relationships between the population trajectories of spinner and spotted dolphins and the marine environment of the ETP, then an appropriate research program must be mounted to measure the critical variables that determine their population dynamics.

Background

Scientists of the Protected Resources Division at the Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS, NOAA) are currently engaged in a suite of studies designed to assess the impact of the eastern tropical Pacific yellowfin tuna (*Thunnus albacares*) purse seine fishery on dolphin stocks (in particular spotted *Stenella attenuata* and spinner dolphins *S. longirostris*) which associate with these tuna. All three regularly associate in mixed species schools (Ballance et al. 2002a). One component of these studies is an assessment of the population size of the potentially affected dolphin stocks. Population assessments have been made for the following years: 1986, 1987, 1988, 1989, 1990, 1998, 1999, and 2000 with a primary goal being to determine if populations that were historically reduced in size are increasing over time. Should the assessments indicate no increase (lack of recovery), three broad categories of factors could be the cause: a) effects from the fishery; b) effects from the ecosystem; c) an interaction between the proceeding two factors.

This need to attribute causality for a potential lack of recovery serves as the primary justification for ecosystem studies. By investigating the physical and biological variability of the ecosystem of which the dolphin stocks are a part, the investigators have attempted to establish a context that can be used to improve the interpretation of trends in dolphin abundance. They argue that a lack of recovery that is not mirrored by some other change in the ecosystem would largely eliminate an ecosystem hypothesis, leaving fishery effects as the most likely cause.

General Topics for Review

This review includes a suite of studies subsumed under the general topic of “Ecosystem Research in the Eastern Tropical Pacific.” The basic approach of the program under review was to compare ecosystem parameters over time with a primary goal of looking for indications of a potential ecosystem shift. The power of these ecosystem studies was assumed to increase with the number of environmental variables, taxa, and trophic levels included, and with the time period spanned. Most available ecosystem data available for these investigations were collected concurrently with dolphin assessment data aboard NOAA research vessels and are restricted to the late 1980s [the 1986-1999 Monitoring of Porpoise Stocks (MOPS) study, and late 1990s (1998-2000), *Stenella* Abundance Research (STAR) project].

The general components included are as follows:

1) Physical and Biological Oceanography: sea surface temperature, thermocline characteristics, phytoplankton and zooplankton distribution and relative abundance;
2) Larval Fishes: distribution and relative abundance;
3) Flying fishes: distribution, relative abundance, and habitat relationships;

4) Seabirds: distribution, absolute abundance, and habitat relationships;
5) Cetaceans: distribution, absolute abundance, and habitat relationships.

Description of Review Activities

To accomplish this review, the ecosystem group at the NMFS SWFSC provided a number of working papers via a web site prior to the Review Meeting, as well as additional materials at the meeting (See Appendix I for a bibliography of materials provided). The Review Meeting was held in La Jolla from 6 to 8 March 2002.

Prior to the meeting, I reviewed all of the papers provided via the web site. I attended the meeting on 6 and 7 March only, as per agreement prior to the meeting, and subsequently continued my review of the materials provided by NMFS SWFSC. This report summarizes a number of the points raised at the Review Meeting, as well as additional thoughts that have arisen since the Review Meeting.

Summary of Findings

The material provided prior to and at the Review Meeting and the presentations at the Review Meeting demonstrate that a great deal of work and thought have been put into the gathering, analyses and interpretation of a wealth of information on the status of the marine ecosystem of the eastern tropical Pacific Ocean (ETP). The scientists and staff involved in this undertaking should be recognized as having accomplished a great deal in a comparatively short period of time. Nevertheless, there is room for further analysis of the material available, and additional work will be required to reveal its full worth. Based on the comments by the NMFS science team, many of these additional analyses are already underway.

The way a question is posed affects its answer. In the case at hand, one wants to know if there is evidence that aspects of the marine ecosystem have changed in such a way that they might be affecting the rate of population recovery in the spinner and spotted dolphins of the ETP. The question can then be put, “Is there evidence that the marine ecosystem has changed significantly?” or it can be put “Is there evidence that the ecosystem has not changed significantly over the period in question?” The second question is much harder to answer than the first. If there is a strong, clear environmental signal, it is relatively easy to demonstrate that the change is statistically unlikely to be the result of chance variation, and one can accept that the change is real. If such change is documented, one can then move on to examine whether it is causally linked with the population trajectories of concern. It is much harder to demonstrate that there have been no environmental changes of significance that could account for the known changes in population trajectory because we have only an incomplete set of measurements of the environment. The lack of an environmental signal in the parameters measured does not mean that some other unmeasured parameter did not change in a manner that affected the populations of concern. In the present case, the relatively restricted suite of measurements taken and the short period over which they are available restricts one’s ability to answer the second question.

Variability in ocean ecosystems occurs over a wide range of spatial and temporal scales. Temporal scales of importance include dial cycles, seasonal cycles, interannual variation, El Niño/Southern Oscillation (ENSO) events, and variability at decadal and longer periodicities. Dial, seasonal, interannual and ENSO events all have strong signals, and may be stronger than signals from climatic events at longer time periods. In the present suite of studies, Fiedler (In Review) and Fiedler and Philbrick (In review) provide an analysis of environmental change in the ETP using observed and reconstructed time series of sea surface temperature (SST) and indices of the Southern Oscillation and the trade winds. These time series vary in length from 350 years for the reconstructed SSTs in the NINO3 series to 30 years or less for other measurements such as thermocline depth in the ETP.

Fiedler and Philbrick (In Review) examined evidence for environmental variability between two periods, 1986-1990, the period of the MOPS (Monitoring of Porpoise Stocks) study, and 1998-2000, the period of the STAR (*Stenella* Abundance Research) project (Balance et al. 2002a). Although they lacked field measurements during the 1997 En Niño event, they concluded that El Niño and La Niña signals in SST and thermocline depth and chlorophyll levels were particularly strong, as were seasonal signals in SST. In contrast, they found no significant differences were found between the measures taken in the 1986-199 period and 1998-2000 except for a very slight warming of a few tenths of a degree C. Unfortunately, they lack the data necessary to make direct comparisons between the 1986-2000 period and the conditions prevalent in the 1960s and 1970s.

Fiedler (In review) extended the analysis of ENSO and decadal-scale variability in the ETP by employing various data sets from the equatorial Pacific Ocean and the reanalysis data sets. Using these, he was able to show that ENSO-scale variability is dominant in the ETP, and that, in the core area of the MOPS and STAR studies, decadal-scale variability in the physical environment is weaker. Within the tropical Pacific Ocean, ENSO events have their greatest effects on the biology of the equatorial and coastal upwelling systems. In contrast to the northeast Pacific Ocean, where decadal-scale regime shifts in 1976 and 1989 were reflected in striking changes in the biological components of marine ecosystems, Fiedler concluded “No regime shift has been detected in the ETP since 1977.” However, the 1989 regime shift of the northeast Pacific Ocean was not particularly strong, and may not have impacted the ETP. There are no direct measurements available to determine if the much stronger 1976 regime shift affected the warm pool at the core of the MOPS and STAR research areas. However, Fiedler used the reanalysis data set to test for effects of the 1976-77 climate shift in the ETP and found that a shift was evident in the slope of cumulative sums of the SST monthly anomaly time series (Fiedler, In Review, fig 7b). Nevertheless, the magnitude of the change was small relative to that of annual or ENSO-scale events

Although there is little evidence of a significant change in the mean state of the physical environment of the ETP, there may be changes in the frequency or amplitude of events such as those associated with ENSO. An increase in the frequency of ENSOs or their severity could stress organisms otherwise adapted to the occasional ENSO event. Thus, it would be of value to analyze the frequency and magnitude of ENSO events in the ETP and to examine how an increased frequency of El Niños might impact the life cycles of elements of the food web on which the dolphins depend.

Few investigations of biological parameters can provide evidence of ETP ecosystem conditions at a time when spotted and spinner dolphins were at their height, i.e., before fishing-related mortality caused a steep decline in dolphin populations. Most time series start with the MOPS data (1986-1990), miss several years, and then resume during the three-year (1998-2000) STAR program. While useful for comparing ecosystem characteristics in the late 1980s and late 1990s, the data sets are inadequate to inform us of whether there were changes in the ETP that began before 1986, when populations of dolphins were already low. At present, we have no way to use the detailed and valuable data from the MOPS and STAR programs to compare conditions before the decline in dolphin numbers with conditions since the heavy losses in the fishery ceased.

Data sets that do suggest some decadal-scale changes in the ETP marine ecosystem are that those of changes in yellowfin and bigeye tuna populations assembled by Maunder and Watters (2001) and Watters and Maunder (2001) as presented in Reilly et al. (2002a). Yellowfin biomass showed a shift to increasing biomass about 1985, whereas bigeye tuna began to decline at about the same time (Reilly et al., 2002a, Fig. 7). As of 1998, the biomass of both species appeared to increase, though there are no data from after 2000 to determine if this was a persistent change. These changes in tuna biomass have come subsequent to the reduction of dolphin populations (mid-1970s), after the 1976 regime shift, and prior to the 1989 regime shift. They suggest that the ETP region may be susceptible to decadal-scale change, but there are insufficient data available to know how to interpret these changes, particularly since these fish are subject to heavy fishing pressure (Reilly et al., 2002a) and it remains extremely difficult to separate the effects of fishing from those of natural environmental variability.

For the most part, the detailed studies of ichthyoplankton (Moser et al., 2002), forage fish and squid (Pitman et al., 2002), marine birds (Balance et al., 2002b), cetacean numbers other than those of spotted and spinner dolphins (Gerrodette and Forcada (2002) and cetacean habitat use (Reilly et al., 2002b) show interannual variability, and variability in response to ENSO events, but little obvious evidence of change between the MOPS study of the late 1980s and the STAR study of the late 1990s. Since there are no data from the period prior to the 1970s when spotted and spinner dolphins were numerous, it seems unlikely that the data presented in these studies can be used to demonstrate that there were no natural changes in the marine environment that could account for the population trajectories of spinner and spotted dolphins since fishing-related mortality declined.

Total ichthyoplankton showed relatively little discernable interannual variation, though there was an indication of higher densities of these organisms in the 1990s data set than in the 1980s data (Moser et al., 2002, Fig. 8). However, the sampling areas were not exactly the same in the two periods, and the heavier sampling of the productive inshore waters in the 1990s may have resulted in a sampling bias that could explain the differences in abundance between the two periods. Individual species or species groups did show considerable interannual variation in both distribution and abundance.

The collections of squid, flying fish and other forage fish with dip nets at the side of the vessel at night provides one of the best data sets available on the distribution and abundance of forage species used by top marine predators. Although only semi-quantitative, these data provide a valuable index of the abundance of these critical links to top predators. Conventional quantitative sampling of forage species is almost completely lacking because of the difficulty of sampling these species. The data assembled by Pitman et al. (2002) demonstrate interannual variability in the distribution and abundance of prey taxa of importance to tunas and dolphins. There is a possible multi-year increase in several taxa between 1987 and 1990. Samples from 1998 were lower than those in 1990, but increased in 1999 and 2000. Pitman et al. raise the possibility that the increases observed may indicate recovery from the El Niño events. The present data set will be extremely useful in assessing future changes in top predator populations with respect to changes in the abundance of these prey.

The analysis of the association of these forage species with habitat variables showed that variation in habitat use was greater within study periods (MOPS and STAR) than it was between study periods. Pitman et al. (2002) explain these differences as reflecting the effects of El Niño events and recovery from them. Pitman et al. point out the similarity of their results to those of Fiedler and Philbrick (In Review), and reiterate that ENSO events are likely to dominate longer-term signals. However, it seems important to remember that signals of various periodicities may be additive in their effects, and that subtle changes in physical parameters may be magnified by biological components of the ecosystem (e.g., Hare and Mantua, 2000). The time series assembled by Pitman et al. does not extend back far enough to determine whether the 1976 regime shift, which apparently had at least a weak signal in the ETP, could have resulted in an overall change in the abundance of forage species.

There is a rich literature demonstrating that the distribution and abundance of seabirds at sea can reflect the distribution and abundance of prey resources (e.g., Ballance et al., 1997). Thus, the monitoring of seabirds in the ETP has the potential of providing an indication of environmental change. Some of the seabird species present in the ETP depend on tuna-dolphin schools for access to prey (Ballance et al., 2002b), and these species may reflect not only the abundance of prey, but also the success of tuna-dolphin schools in finding prey and driving it to the surface. Other seabird species not dependent on tuna-dolphin schools may reflect the productivity of the ecosystem as a whole. Because most species of seabirds using the ETP are not breeding within the study area and are free of the need to return frequently to their nests, they are able to respond to variations in prey availability and shift their distributions to reflect access to prey. These responses can result in shifts in distribution within the ETP, or changes in the numbers of birds assembling in the ETP to forage.

The analyses of the distributions and abundances of seabirds in the ETP arrive at much the same conclusions as those for the forage species: there are species and guild-specific patterns in distribution and abundance, there is interannual variation, and the responses of seabirds over time are stronger at the time scale of El Niño events than between the 1980s and the 1990s (Ballance et al., 2002b). Although one species, the Tahiti Petrel (*Pseudobulweria rostrata*), showed a population decline over the two decades of study, this decline was believed to relate to events on the breeding colonies distant from the ETP, rather than environmental change within the ETP (Ballance et al., 2002b).

Additional analyses may reveal subtle changes in the behavior of seabirds that could reflect changes in the abundance of prey. Recent work suggests that seabird distributions at sea may vary in the degree of clumping as a function of prey resource density (D. Hyrenbach, PhD Thesis, Scripps Institution of Oceanography). It might therefore be of value to explore whether the size or spatial distribution of seabird flocks in the ETP have changed over time. It would also be of value to know if the proportion of flocks seen with tuna-dolphin schools has changed, or whether the proportion of flocks observed foraging has changed. Since bird flock activity has been recorded since 1979 (Ballance et al., 1997), these analyses have the potential of extending the time series back to an earlier decade.

Several species of cetaceans, in addition to spotted and spinner dolphins, are found within the ETP. The distributions and abundances of these species may also provide useful indices of environmental change in the ETP, as they may utilize a similar suite of prey species as the spinner and spotted dolphins. Although most species studied did not change in abundance over the period from the 1980s to the 1990s, two taxa, the northern stock of the short-beaked common dolphin (*Delphinus delphis*) and the short-finned pilot whale (*Globicephala macrorhynchus*), showed significant linear increases (Gerrodette and Forcada, 2002). The cause of this increase is not known. However, it raises the more general question that predators other than spinner and spotted dolphins may have increased in the absence of competition from the dolphins once their numbers were reduced. The recovery of the dolphins could be seriously compromised if a new suite of consumers is now taking the prey formerly available to them.

Although not attached to their paper, data from Gerrodette and Focada (2002) presented in Reilly et al. (2002a) show patterns that do suggest that most species of “non-target” cetaceans showed changes in population size that might reflect decadal-scale increases or decreases (Reilly et al., 2002a, Fig 10). Although individually most of these patterns of population change are not statistically significant, it is possible that with appropriate analyses one might find that the shifts between the MOPS years and the STAR years are stronger than would be expected by chance. As in the case of the seabird analyses, it would also be useful to determine whether the degree of clumping, size, or frequency of observed foraging of cetacean groups has varied over the time of the study.

Where possible, it would be useful to examine whether any of the data gathered prior to 1986 could be used in these analyses.

The analyses of habitat use by dolphins showed considerable overall similarity in habitat use at both interannual and longer time scales, though the variance explained by the ordination analyses was not great (Reilly et al., 2002b). Biplots for the MOPS and Star years varied somewhat (Reilly et al., 2002b, Fig. 4a,b), but these subtle differences may have reflected differences in the survey design between the two studies, rather than a significant shift in habitat use.

Overview

Although it is extremely fortunate that the suite of environmental variables gathered in the MOPS and STAR programs are available, their value will be principally realized in coming decades as the fate of the ETP ecosystem is followed through time. They will provide a most useful snapshot of what the system was like in the 1980s and 1990s, and in time may help develop predictions about the responses of biological components of the marine ecosystem to changes in marine climate. However, these time series are too short to allow determination of whether environmental shifts since the decline of the spotted and spinner dolphin stocks in the ETP have affected dolphin recovery. For that, time series extending back to at least the early 1970s would be needed. There is also a lack of important information on the trophic linkages of the species in question and on the rates of transfer. Although standing stocks, as measured in the MOPS and STAR programs may have shown little overall change, little is known about the rates of production and the efficiencies of transfer of energy to upper trophic levels, either of which could affect the rates of growth of dolphin populations.

Throughout the studies, there was a tendency to equate a lack of change between the MOPS and STAR studies with a lack of decadal-scale change in the ETP ecosystem. Although the two studies occurred for the most part in different decades and about a decade apart, it is inappropriate to assume that decadal-scale changes in the marine environment will coincide with calendar decades. Decadal-scale changes may occur over a diversity of time periods, and with considerable variation in strength. In the northeast Pacific Ocean, the 1976 regime shift had a strong signal in both climate indices and in biological responses whereas the 1989 regime shift was hard to detect in the climate signals, but caused strong responses in a limited number of biological indices (Hare and Mantua, 2000). It is hardly surprising that with such a short set of time series in the ETP that few decadal-scale effects were found. Those that were present, a change in the biomasses of two species of tuna and a shift in the cumulative sums of SST, suggest that the possibility of decadal-scale changes in the ETP cannot be dismissed.

The strength of a climate or physical signal cannot be assumed to affect a biological response in a linear fashion. In most cases we do not know the mechanisms linking variation in marine climate properties to response of biological components of the marine ecosystem. In those where we think we are beginning to understand the linkages, there is evidence that the biological responses are non-linear (e.g., Hunt et al., In Press). Thus a weak signal in the physical realm that pushes a biological parameter over a threshold may cause a disproportionately great change in the biological component. It is possible that secular trends or decadal-scale shifts the 1970s that were not detected in the time series examined have caused significant decreases in the ability of the ETP to support upper trophic level organisms. The slowing of the meridional overturning circulation and the consequent reduction of upwelling in the equatorial divergence since the 1970s is a case in point (McPhaden and Zhang, 2002). How a change of this sort would affect marine ecosystem of the ETP warm pool is not known. Secular changes, such as the shoaling of the thermocline in the ETP (Fiedler, In Review), may result in a like shift in a biological parameter or they may trigger an abrupt biological change if they pass a threshold.

Because there are numerous temporal scales of variation and because the effects of these variations may be additive, demonstration that a particular periodicity of variation is less than another does not mean that it cannot have a significant impact on the ecosystem. In the northeast Pacific Ocean, seasonal, interannual and ENSO signals can be greater than decadal-scale signals. Nevertheless, there have been strong biological responses to decadal-scale shifts in climate (Hare and Mantua, 2000). These decadal-scale shifts in atmospheric circulation may have coincided with ENSO and annual variability to force significant changes in the marine ecosystem that might not have resulted had not there been a coincidence of signals (J. Overland, PMEL/NOAA, Pers. Com.).

Although there may be some concern that changes in seabird and cetacean numbers within the ETP may reflect changes outside of the ETP, rather than within the study area, the wide variety of species used lessens the possibility of misinterpretation of changes within the ETP. Seabird species include those that breed in the northern and southern hemisphere and which have very different foraging strategies. Likewise, the cetaceans chosen for monitoring include populations that remain in the ETP as well as those that move between the ETP and waters to the north and south. Thus, in sum, these species of birds and mammals should be useful indicators of major changes in the ETP marine ecosystem.

Conclusions/Recommendations

The environmental data gathered in the MOPS and STAR programs provide extremely important time series for examining correlations between variability in the marine climate and the responses of upper trophic level organisms to this change. If these time series are kept up in the future, they will become increasingly valuable for providing data of critical importance to management of the tuna fisheries. We have become increasingly aware that marine ecosystems vary over a variety of time scales, and that management models that do not take account of this variability are likely to fail. The developing time series of seabird and cetacean population size and habitat use will provide the data needed to assess the success of ecosystem-based fishery management in the ETP. They, and the other indices of ichthyoplankton and forage species, have already provided evidence of the spatial and temporal scales over which this ecosystem responds most strongly to atmospheric forcing.

The indices of the state of the marine ecosystem in the ETP, including physical measurements, chlorophyll abundance, ichthyoplankton abundance, and the distributions and abundances of seabirds and cetaceans, all suggest a system that is relatively stable over the long haul, and that has its strongest temporal responses at the time scale of ENSO events. There is little evidence to support a strong environmental change between the MOPS study (1986-1990) and the STAR study (1998-2000). The time series are too short to address the question of whether there has been a significant change in the marine ecosystem between the time when spotted and spinner dolphins were abundant in the ETP (e.g., prior to the 1970s) and more recent times subsequent to the reduction of dolphin mortality rates in the tuna fishery.

If it is important to determine the causal relationships between the population trajectories of spinner and spotted dolphins and the marine environment of the ETP; then an appropriate research program must be mounted to measure the critical variables that determine their population dynamics. In addition to investigating how fishing activities may impact these dolphins, there is a need to determine their prey preferences and what determines the abundance and availability of these prey to the dolphins. Knowledge of the relationship between the dolphins and the dominant species of tuna, are the tunas competitors or facilitators of dolphin foraging, is needed. What controls the populations of prey species, and how does climate influence the efficiency of transfer of primary production to end users are relevant questions requiring answers. Without an examination of rates of production and transfer, it will be most difficult to demonstrate the relative effects of fishing and environmental change on the recovery of spinner and spotted dolphin populations.

Although a thorough study of the marine ecosystem of the ETP would be desirable, it may be possible to extract additional information from existing data sets that could help to resolve whether there have been significant changes in the ecosystem that may have affected spinner and spotted dolphins there. These include:

1) **Analyze the frequency and magnitude of ENSO events in the ETP and determine how an increased frequency or magnitude of El Niños might impact the life cycles of elements of the food web on which the spinner and spotted dolphins depend.**

2) **Determine whether the size or spatial distribution of seabird flocks in the ETP have changed over time.**

3) **Determine whether the proportion of bird flocks seen with tuna-dolphin schools has changed, and whether the proportion of flocks observed foraging has changed. Because bird flock activity has been recorded since 1979 (Ballance et al., 1997), these analyses have the potential of extending the time series back to an earlier decade.**

4) **Determine whether the degree of clumping, size, or frequency of observed foraging of cetacean groups has varied over time. Where possible, it would be useful to examine whether data gathered prior to 1986 could be used in these analyses.**

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Appendix I: Bibliography of Materials Provided

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* Document requested by reviewers.

Appendix II: STATEMENT OF WORK

STATEMENT OF WORK

Consulting Agreement Between The University of Miami and Dr. George Hunt

Background

Scientists of the Protected Resources Division at the Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS, NOAA) are currently engaged in a suite of studies designed to assess the impact of the eastern tropical Pacific yellowfin tuna purse seine fishery on dolphin stocks which associate with these tuna. One component of these studies is an assessment of the population size of the potentially affected dolphin stocks. Population assessments have been made for the following years: 1986, 1987, 1988, 1989, 1990, 1998, 1999, and 2000 with a primary goal being to determine if populations that were historically reduced in size are increasing over time. Should the assessments indicate no increase (lack of recovery), three broad categories of factors could be the cause: a) effects from the fishery; b) effects from the ecosystem; c) an interaction between the proceeding two factors.

This need to attribute causality for a potential lack of recovery serves as the primary justification for ecosystem studies. By investigating the physical and biological variability of the ecosystem of which the dolphin stocks are a part, we establish a context that can be used to better interpret trends in dolphin abundance. A lack of recovery that is not mirrored by some other change in the ecosystem would largely eliminate an ecosystem hypothesis, leaving fishery effects as the most likely cause.

It should be noted that this issue is controversial and particularly relevant to persons involved with NMFS, the US and non-US tuna industry, and environmental groups.

General Topics for Review

This review includes a suite of studies subsumed under the general topic of "Ecosystem Research in the Eastern Tropical Pacific." Our basic approach will be to compare ecosystem parameters over time with a primary goal being to look for indications of a potential ecosystem shift. The power of these ecosystem studies will increase with the number of environmental variables, taxa, and trophic levels included, and with the time period spanned (although most ecosystem data available for these investigations were collected concurrently with dolphin assessment data aboard NOAA research vessels and are restricted to the late 1980s and late 1990s).

The general components included are as follows:

> Physical and Biological Oceanography: sea surface temperature, thermocline characteristics, phytoplankton and zooplankton distribution and relative abundance;
>
> Larval Fishes: distribution and relative abundance;
>
> Flyingfishes: distribution, relative abundance, and habitat relationships;
>
> Seabirds: distribution, absolute abundance, and habitat relationships;
>
> Cetaceans: distribution, absolute abundance, and habitat relationships.

Potential reviewers should be familiar with one or more of the following general disciplines: physical oceanography, biological oceanography, pelagic (oceanic) ecology of plankton, fish, birds, and cetaceans. Analysis methods will include use of certain multivariate techniques such as Canonical Correspondence Analysis and Generalized Additive Models. Familiarity with one or more of the taxa listed above will be helpful. Due to the broad scope of components included within this investigation, no single reviewer will be expected to have expertise in all relevant areas.

Documents supplied to reviewers will include draft manuscripts on topics listed above. A number of background papers (relevant publications and reports) will also be supplied.

Specific Reviewer Responsibilities

The reviewer=s duties shall not exceed a maximum total of two weeks: several days to read all relevant documents, three days to attend a meeting with scientists at the NMFS La Jolla Laboratory, in San Diego, California, and several days to produce a written report of the reviewer=s comments and recommendations. It is expected that this report shall reflect the reviewer=s area of expertise; therefore, no consensus opinion (or report) will be required. Specific tasks and timings are itemized below:

1. Read and become familiar with the relevant documents provided in advance;

2. Discuss relevant documents with scientists at the NMFS La Jolla Laboratory, in San Diego, CA, for 3 days, from March 6-8, 2002;

3. No later than March 22, 2002, submit a written report of findings, analysis, and conclusions. The report should be addressed to the AUM Independent System for Peer Reviews, A and sent to David Die, UM/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149 (or via email to ddie@rsmas.miami.edu).